Review on Calibration of $\tau \rightarrow \mathrm{bjet}$ Mis-tagging

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Overview

Introduction

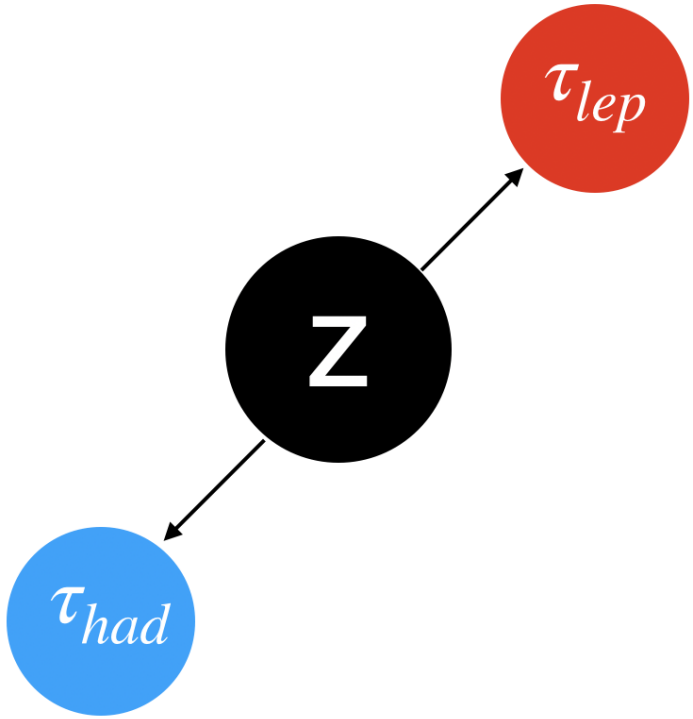
- Qualification task:
  - Release 21 $\tau \rightarrow$b-jet mis-tag calibration using $Z \rightarrow \tau\tau$ tag-and-probe technique
- B-tagging
  - many interesting physics signatures produce a final state b-quark(top, higgs, ...)
  - hadronise and shower, reconstructed as b-jet
  - to differentiate b-jets from others(c-jets, light jets)
  - three baseline algorithms(IP, SV, JetFitter)+one BDT method(MV2c)

Samples

- data: 43.59 fb^{-1} recorded by ATLAS detector at LHC in 2017
- mc samples: mc16d
  - $Z \rightarrow \tau\tau$: Sherpa
  - $Z \rightarrow \ell\ell$: POWHEG with Pythia8
  - W+jets: Sherpa
  - Top: POWHEG with Pythia8

Event Selection

- select Z$\rightarrow \tau_{lep}\tau_{had}$ events:
  - μ(SL trigger, isolated, medium), τ(loose/medium/tight)
  - $p_T^{\ell} < 40$ GeV, $p_T^{\tau} > 20$ GeV
  - OS, $|\Delta\phi(\ell, \tau)| > 2.4$
  - $45 < m_{vis}(\ell, \tau) < 120$ GeV
  - numbers of τ tracks: 1 or 3

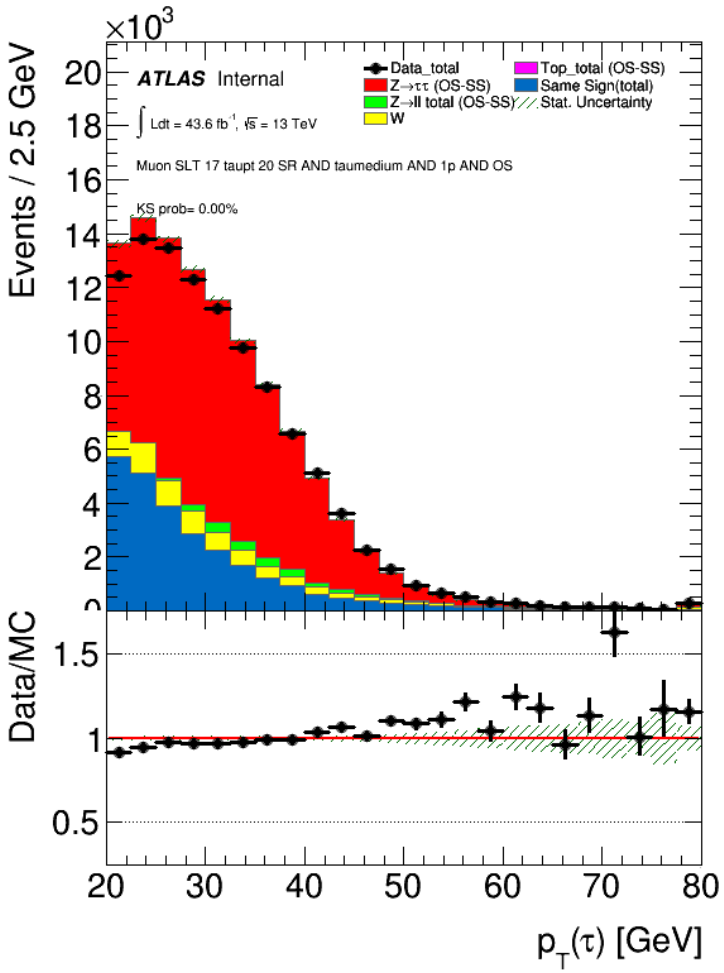


Backgroud Estimation

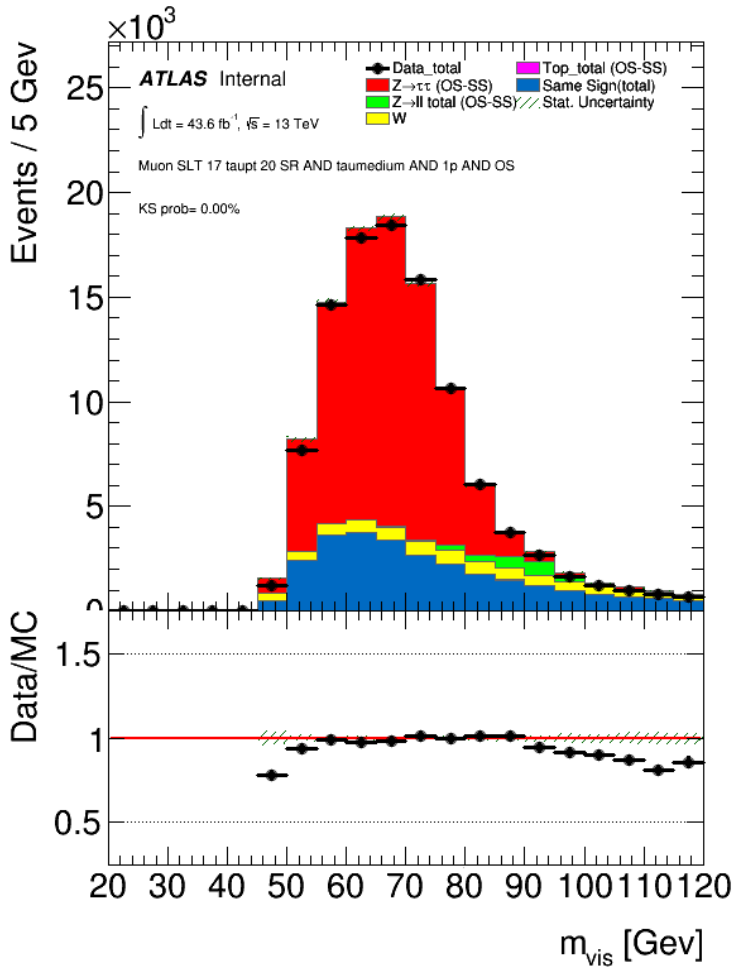
- Simulated samples: top, W+jets, $Z \to \ell\ell$
- Data-driven: multi-jets, OS-SS method
  - $N_{OS}^{MJ} = r_{QCD}(N_{SS}^{data} - N_{SS}^{Z\to\tau\tau} - N_{SS}^{Z\to\ell\ell} - k_{SS}^{W} N_{SS}^{Wjets} - k_{SS}^{top} N_{SS}^{top})$
  - $N_{OS}^{bkg} = N_{OS}^{MJ} + N_{OS}^{Z\to\tau\tau} + N_{OS}^{Z\to\ell\ell} + k_{OS}^{W} N_{OS}^{Wjets} + k_{OS}^{top} N_{OS}^{top}$
- OS-SS method
  - r_{QCD}: QCD CR,
    $r_{QCD} = (N_{OS,qcdCR}^{data} - N_{OS,qcdCR}^{mc})/(N_{SS,qcdCR}^{data} - N_{SS,qcdCR}^{mc})$
  - $k_{OS/SS}^{W}$: WCR,
    $k_{OS/SS}^{W} = (N_{OS/SS,WCR}^{data} - N_{OS/SS,WCR}^{mc'})/(N_{OS/SS,WCR}^{Wjets})$
  - $k_{OS/SS}^{top}$: TCR,
    $k_{OS/SS}^{top} = (N_{OS/SS,TCR}^{data} - N_{OS/SS,TCR}^{mc'})/(N_{OS/SS,TCR}^{top})$

Backgroud Estimation

- 1-prong, medium TauID, 70% b-tagging WP



(a) tau pT



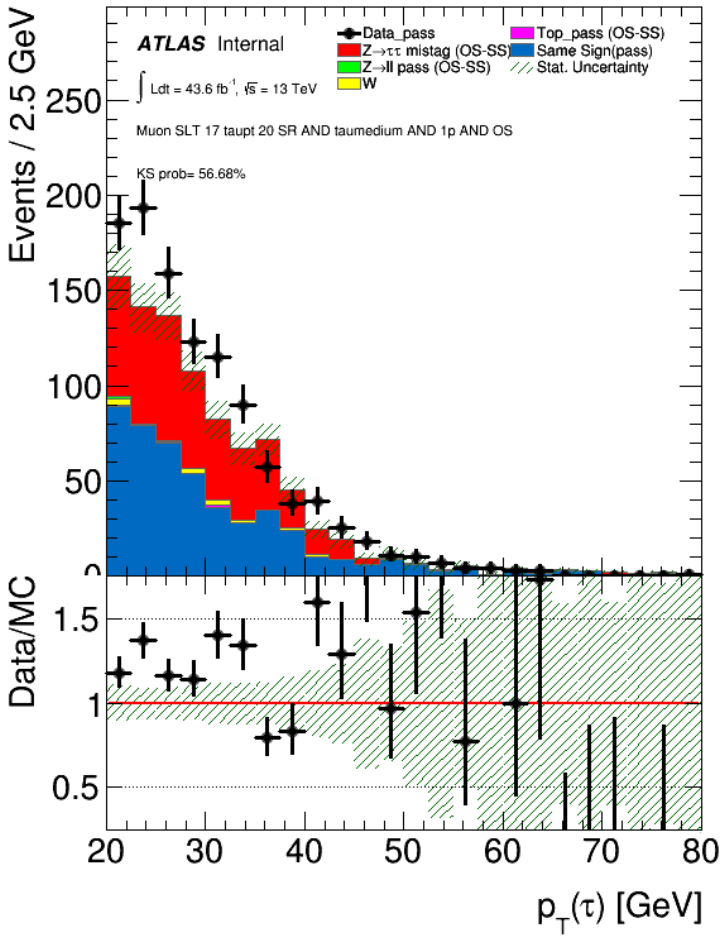
(b) vis-mass

B-tagging on τ Candidates

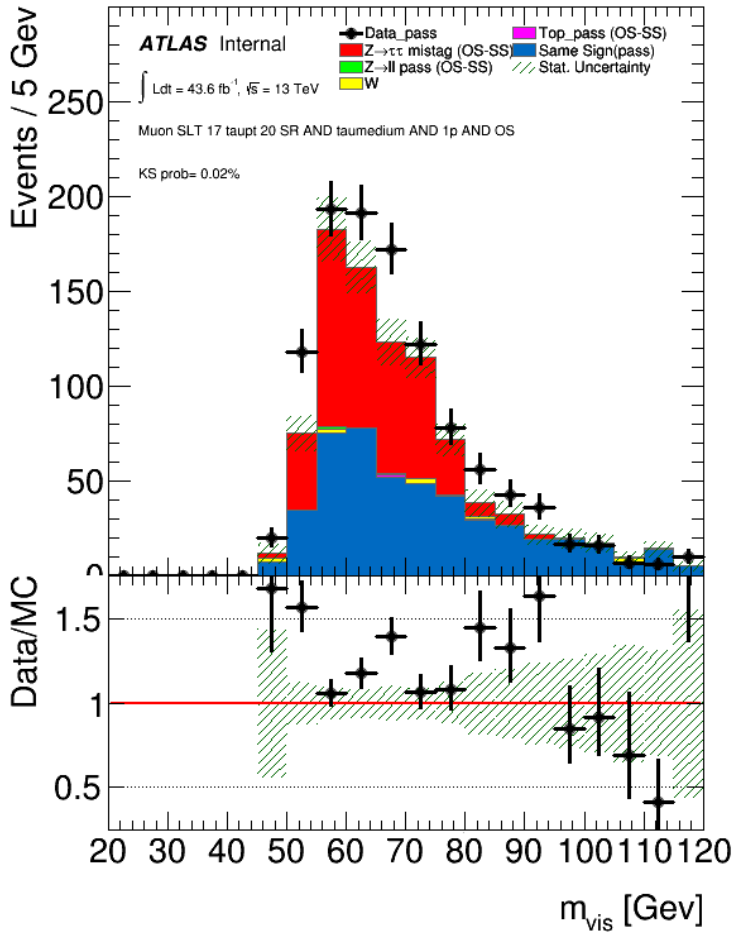
- based on MV2c10
- There is a problem in rel21 retriving the b-tagging decision for the jet associated to a τ.
- τ is seeded from LC jets while b-tagging is supported only for EM jets.
- Quick solution:
  - Find the EM jet nearest to the LC jet associated to τ and apply b-tagging on this EM jet.

B-tagging on τ Candidates

- 1-prong, medium TauID, 70%b-tagging WP



(a) tau pT



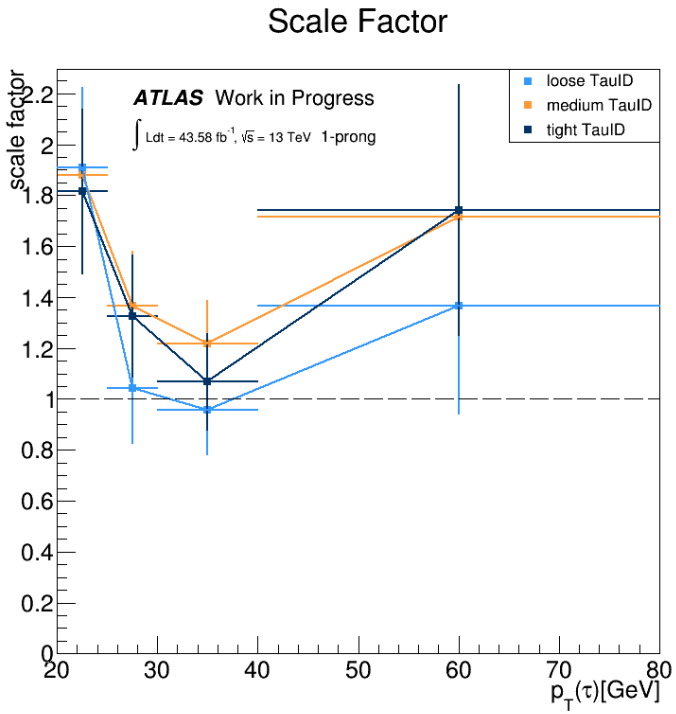
(b) vis-mass

Mis-tagging Efficiency and Scale Factor

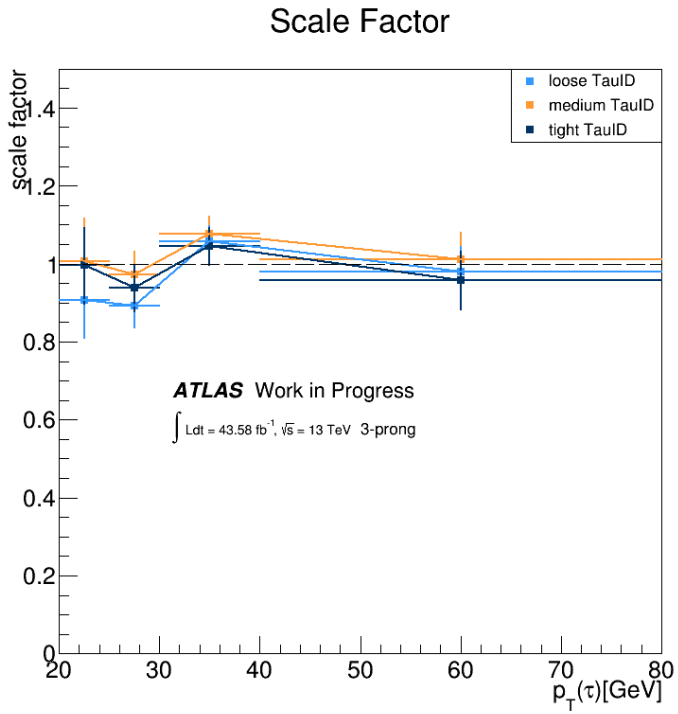
- mis-tagging efficiency:
  - use TEfficiency class to calculate this mis-tagging efficiency
  - statistics option: kFNormal(normal approximation)
  - confidence level: 0.68
  - $\varepsilon = N_{pass}/N_{total}$
- scale factor: SF$= \varepsilon_{data}/\varepsilon_{mc}$

Results

- 70% b-tagging WP



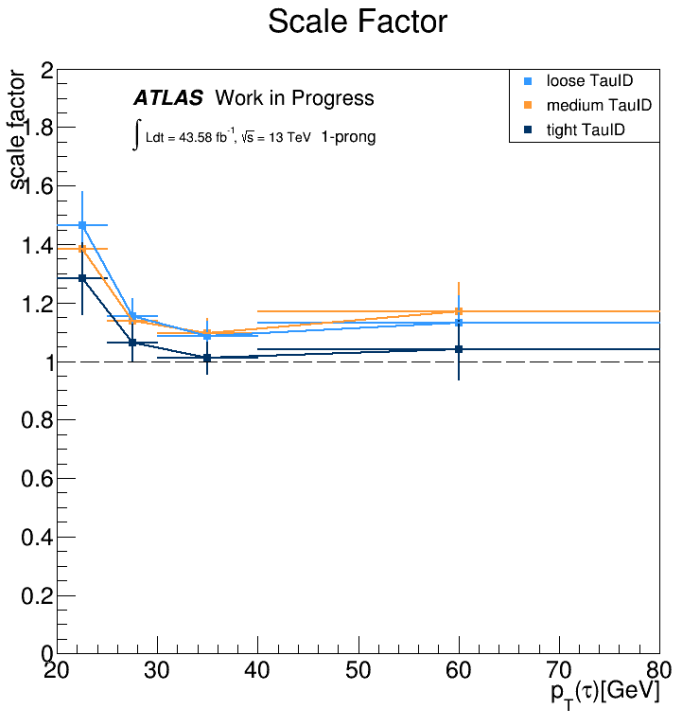
(a) 1-prong



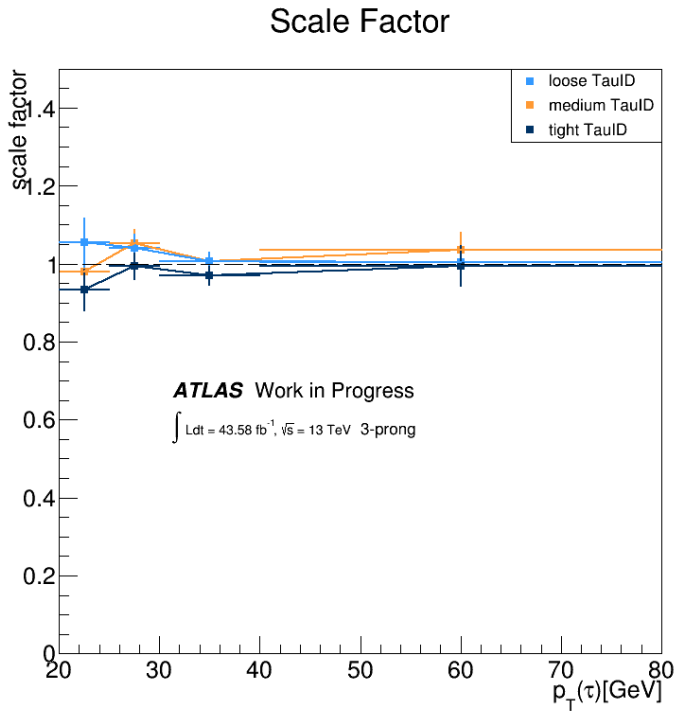
(b) 3-prong

Results

- 85% b-tagging WP



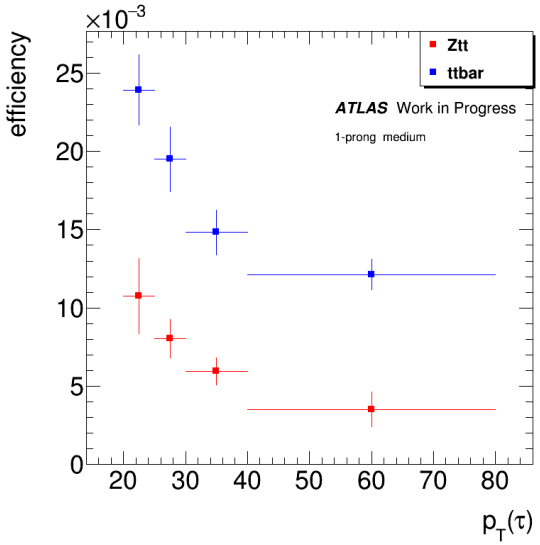
(a) 1-prong

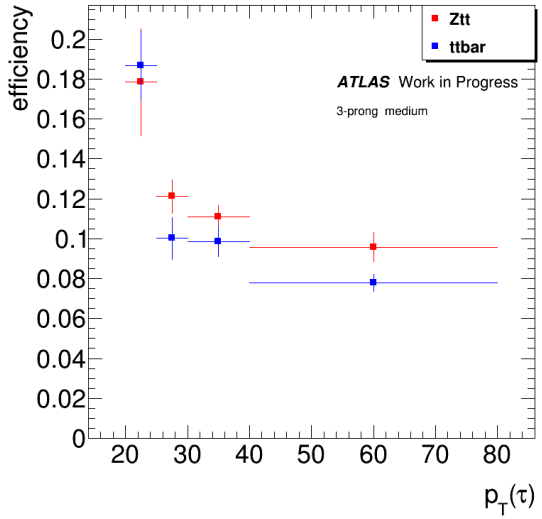


(b) 3-prong

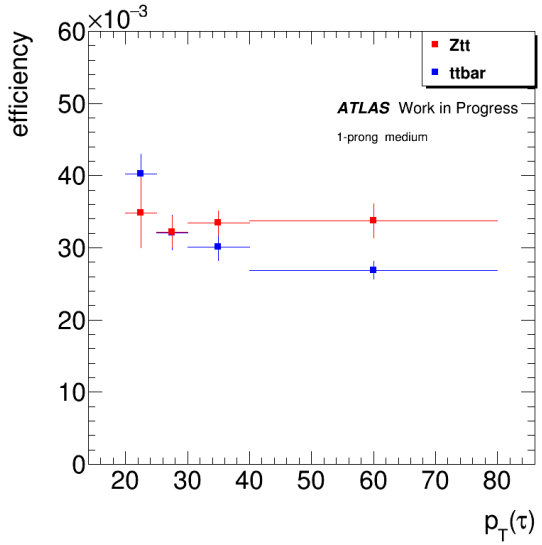
Others: $Z \to \tau\tau$ v.s. $t\bar{t}$

- find that the mis-tagging efficiency is quite different between $Z \to \tau\tau$ and $t\bar{t}$ MC samples
- might due to the cuts on number of τ tracks





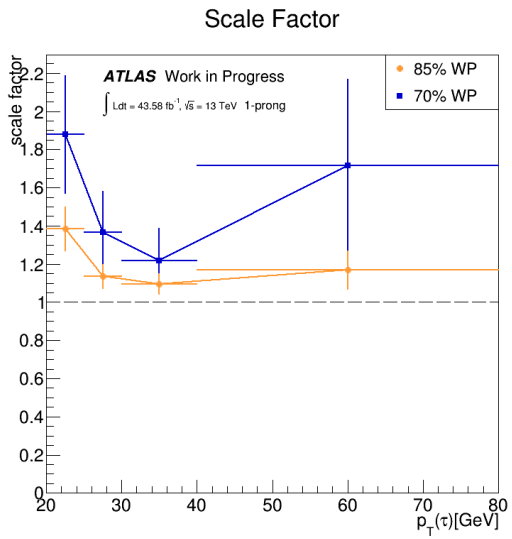
(a) with ntrack cut

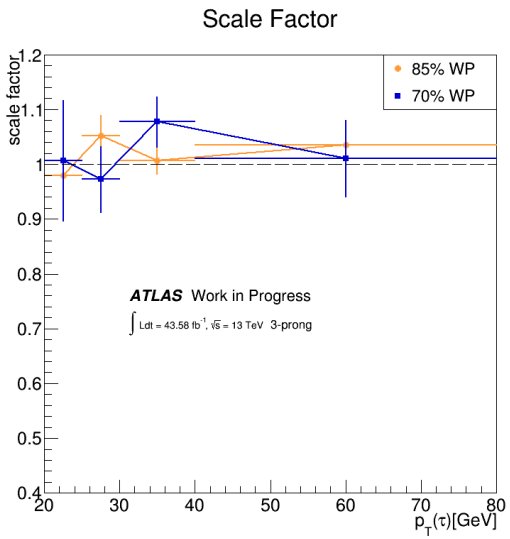


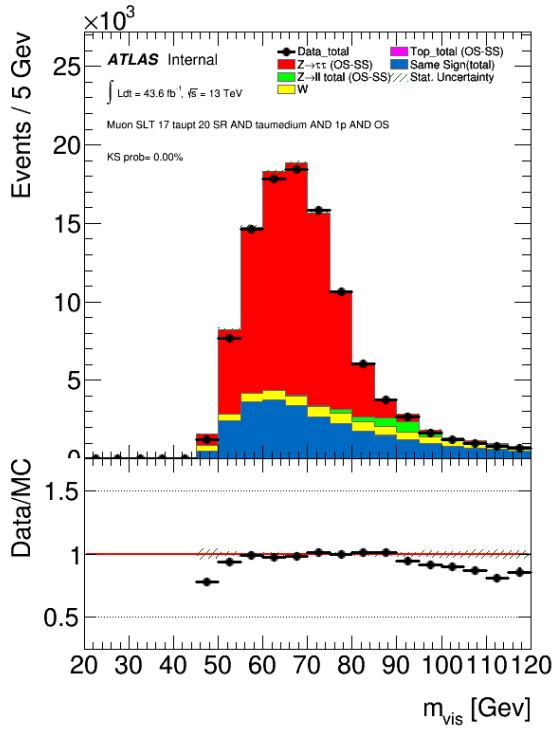
(b) without ntrack cut

To-Do List

- make comparison of SFs between different b-tagging WPs(60%, 70%, 85%)
- improvement on vissible mass cut





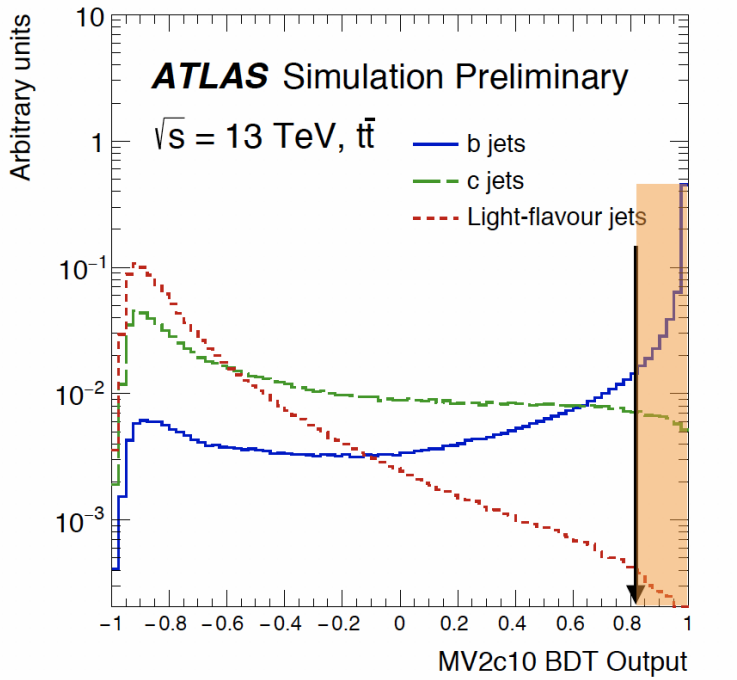


The End

Backups

B-tagging

- MV2cXX: trained on a sample with XX% c-jets(100-XX% light jets)
- working point



Scale Factors: 70% WP

- Release21: data17/mc16d
- Different TauID WPs, 70% b-tagging WP

1-prong

	$20 < p_T(\tau) < 25$	$25 < p_T(\tau) < 30$	$30 < p_T(\tau) < 40$	$40 < p_T(\tau) < 80$
Loose	1.91±0.32	1.04±0.22	0.96±0.17	1.37±0.43
Medium	1.88±0.31	1.36±0.22	1.22±0.17	1.72±0.45
Tight	1.82±0.32	1.33±0.24	1.07±0.19	1.74±0.49

3-prong

	$20 < p_T(\tau) < 25$	$25 < p_T(\tau) < 30$	$30 < p_T(\tau) < 40$	$40 < p_T(\tau) < 80$
Loose	0.91±0.10	0.89±0.06	1.06±0.04	0.98±0.07
Medium	1.01±0.11	0.97±0.06	1.08±0.05	1.01±0.07
Tight	1.00±0.10	0.94±0.06	1.05±0.05	0.96±0.08

Scale Factors: 85% WP

- Release21: data17/mc16d
- Different TauID WPs, 85% b-tagging WP

1-prong

	$20 < p_T(\tau) < 25$	$25 < p_T(\tau) < 30$	$30 < p_T(\tau) < 40$	$40 < p_T(\tau) < 80$
Loose	1.46±0.12	1.15±0.06	1.09±0.05	1.13±0.09
Medium	1.39±0.11	1.14±0.06	1.10±0.05	1.17±0.10
Tight	1.28±0.12	1.06±0.07	1.01±0.06	1.04±0.10

3-prong

	$20 < p_T(\tau) < 25$	$25 < p_T(\tau) < 30$	$30 < p_T(\tau) < 40$	$40 < p_T(\tau) < 80$
Loose	1.06±0.06	1.04±0.04	1.01±0.02	1.00±0.04
Medium	0.98±0.05	1.05±0.04	1.01±0.02	1.03±0.05
Tight	0.93±0.05	0.99±0.03	0.97±0.02	0.99±0.05